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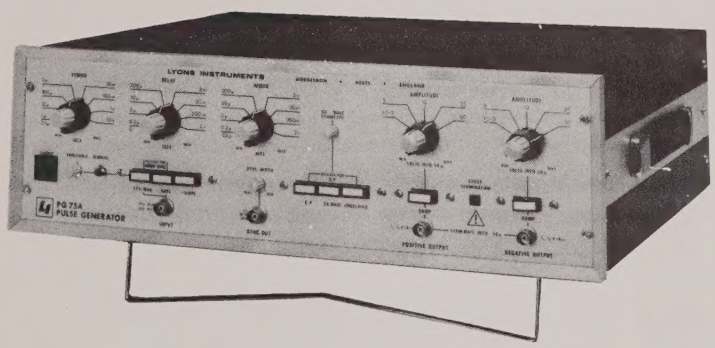
LYONS INSTRUMENTS

OPERATING AND SERVICING MANUAL

TYPE PG-75A

PULSE GENERATOR



CAUTION

THE PG–75A PRODUCES HIGH POWER OUTPUTS i.e. 50V INTO 50 OHMS. THE USER IS ADVISED TO READ SECTION 4 BEFORE ATTEMPTING TO USE THIS PULSE GENERATOR.

NO LIABILITY CAN BE ACCEPTED FOR DAMAGE CAUSED BY IMPROPER USE OR FAILURE TO OBSERVE THE PRECAUTIONS NOTED IN SECTION 4.

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Designed and manufactured in England by

LYONS INSTRUMENTS LIMITED

HODDESDON · HERTS · ENGLAND HODDESDON 67161 · TELEX 22724

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SECTION 1

SPECIFICATION

1.1.	Pulse Amplitude	50 volts into 50 ohms ±5% from simultaneous positive and negative outputs. Amplitude variable to 1·5 volts in four 6 dB attenuator steps plus vernier control of 2:1 range. Both outputs are short circuit and open circuit protected. Duty cycle up to 100% obtainable. (50 watts continuous).
1.2.	Pulse Shape	Rise time less than 10 nanoseconds. Fall time less than 10 nanoseconds. Overshoot and ringing less than 5% of amplitude (minimum setting less than 7%).
	NOTE:	1.1. and 1.2. apply only when outputs are terminated with 50 ohms via cable of that impedance.
1.3.	Pulse Width	Variable from 30 nanoseconds (nominal) to greater than 2 seconds. Jitter less than 0·1% of value +0·4 nanoseconds.
1.4.	Delay	Variable from -10 nanoseconds to greater than +2 seconds with respect to the sync. pulse output. Jitter less than 0·1% of value +0·4 nanoseconds.
1.5.	Sync. Pulse	1·5 volts positive into 50 ohms, at clock or external repetition rate. Width variable 15 nanoseconds to 85 nanoseconds. (These figures are typical).
1.6.	Pulse Mode	
	1.6.1. Normal	Output pulse width and delay controllable in conventional manner.
	1.6.2. Complement	Outputs inverted but not shifted with respect to ground. The operation of width control reversed. Minimum width setting may vary from NORMAL.
	1.6.3. Delayed Pulse	One output pulse per period appearing at each output with time delay control of the pulse with respect to sync. output (or external input).
	1.6.4. Undelayed Pulse	As for Delayed Pulse but output occurs at a fixed delay (+30 ns approx.) with respect to sync. output.

1.6.5.	Double Pulse	Output pulses occuring in pairs, one pulse at each output at a fixed delay with respect to the sync. pulse, the second pulse variable in delay by means of Delay controls.
1.6.6.	Square Wave	Output pulses at clock rate with nominal 50/50 Mark/Space ratio. Symmetry adjustable $\pm$7% nominal. Width and Delay circuits inoperative.
1.7.	Repetition Period	10 seconds to 100 nanoseconds (0·1 Hz to 10 MHz) in eight ranges plus vernier. Jitter typically less than 0·1% of period +0·4 nanoseconds.
1.8.	External Input	
1.8.1.	Sensitivity	1V peak into high impedance (1kΩ, 27 pf. approx.)
1.8.2.	Threshold	+2V to -2V adjustable at the front panel.
1.8.3.	Slope	Negative or Positive selectable at the front panel.
1.8.4.	Sync.	Rate generator synchronised to external signals. Pull in range typically 10% of set frequency.
1.8.5.	Gate	Synchronous gating of the rate generator by means of external signals. Sensitivity, etc., as 1.8.1. and 1.8.2.
1.8.6.	External	Input socket protected to $\pm$50V at 25% duty cycle and 30V D.C.
1.9.	Power Requirements	100-125V or 200-250V, 47-65 Hz, 300 watts.
1.10.	Weight	18.2 kg (40 lbs)
1.11.	Environment	Operating temperature: 0°C to +50°C Operating humidity: Up to 70% RH. Storage temperature: -10°C to + 65°C.

Specifications unless otherwise stated are those of a typical instrument.

SECTION 2

DESCRIPTION OF CONTROLS

2.1. WARNING — Do not directly connect the outputs of the PG-75A to other outputs or voltage sources.

WARRANTY — The instrument is subject to a one-year warranty, effective at our works, full details of which are given in Section 6.

On receipt of the instrument please check for signs of mechanical damage in transit. Should such damage be evident, do not attempt to use the instrument but contact Lyons Instruments Limited, or their agent in your country immediately. Do not attempt to repair or return the instrument without first contacting us.

2.2. Controls and Connectors - General - see Fig. 2-1

The controls of the PG-75A provide a large number of configurations in the use of the instrument. As with all variable pulse generators, it is possible to set the controls in a manner where the settings are not compatible with each other, for instance selecting too high a repetition rate for the set width and/or delay. Such settings must be avoided if proper results are to be obtained.

A brief description of each control and its operation follows.

2.3. Power Switch POWER

The POWER switch connects AC to the mains transformer primary when pushed. The illuminated button lights and the sound of the cooling fan should be heard.

2.4. PERIOD

The rotary switch of this dual concentric control selects one of the eight repetition rate ranges. The vernier control provides continuously variable settings for all ranges. Fully clockwise rotation of this control sets the longest period per range and overlap at each range setting is provided.

2.4.1. Gate/Sync/Ext - Slope - Threshold - Manual Period Mode Selector

A three button selector switch is fitted.
Two positions control the period generator operating mode and the third selects the operating slope of any applied external input.

Sync/Normal

The period generator freely runs at the setting of the range switch and vernier or can be synchronised to an external input.

Gate

With this button pressed the period generator can be gated 'On' or 'Off' by an applied external input. The slope button determines 'gate on' or 'gate off'.

Ext.

With this button pressed the internal period generator is off and the external input signal triggers the pulse generator. The slope switch may be used to select the active slope of the input signal.

Threshold Control

A preset potentiometer which allows the threshold or trigger point of an input signal to be varied ± 2 volts.

2.5. DELAY

The DELAY rotary switch selects one of eight ranges and the concentric vernier provides continuously variable control and overlap for each range. Clockwise rotation of the vernier control sets the maximum delay at each range.

2.6. WIDTH

The WIDTH rotary switch operates in the same way as the DELAY control; fully clockwise rotation of the vernier control sets the maximum pulse width on each range.

2.7. DP/DELAY/UNDELAYED/SQUARE WAVE

2.7.1. A three button push switch selects one of four modes of operation of the PG-75A. The DELAY (single pulse) position is selected with all buttons out and a single output pulse occurs at each output for every clock period. The DELAY range has a negative minimum limit with respect to the sync. pulse.

2.7.2. The DP button selects the double pulse mode and allows an effective output pulse rate of approximately 20 MHz to be obtained by producing two output pulses during every clock period. The first pulse is fixed with respect to the sync. pulse, and the time relationship of the second is set by the DELAY control. The width of both pulses is variable by means of the WIDTH control.

2.7.3. With the SQ. WAVE button depressed, the width and delay controls are inoperative and the outputs are in the form of a square wave. Symmetry is adjustable at the front panel (SYM ADJ).

2.7.4. The UNDELAYED button disconnects the delay generator completely and allows the output pulse to be produced at minimum delay with respect to external input or sync output signal.

2.8. NORMAL/COMPLEMENT

These two switches allow the pulses fed to the output stages to be inverted whilst retaining their ground reference. Thus, in the NORMAL mode, operation of the WIDTH control is as described in 2.6. In the COMPLEMENT mode, the effect of the WIDTH control is reversed, allowing very large duty cycles to be obtained at either output. It should be noted that as the output stage has to operate in the saturated mode, minimum width conditions will occur at slightly different settings of the WIDTH control.

2.9. AMPLITUDE

These dual concentric controls allow the outputs to be continuously varied over a 30 dB range: outputs must be terminated in 50 ohms in the 25 to 50 volt position to obtain any output pulse and the instrument is designed to operate into 50 ohms at all settings.

2.10. OUTPUT

The two BNC sockets provide the output connections of the instrument.

2.11. SYNC AND SYNC WIDTH

This BNC socket supplies the reference trigger pulse at the clock rate (or external signal rate). The SYNC WIDTH control varies the width of the sync. pulse, fully clockwise rotation giving minimum width.

2.12. OVERLOAD PROTECTION

The PG-75A is fitted with an automatic overload protection system which disconnects the pulse source from the output and lights a warning indicator. Immediately the overload is removed the circuit resets itself and hence a continual overload is indicated by the lamp flashing.

Overload indications can occur during normal operation, i.e. during the warming-up period (approx. 5 minutes), when carrying out certain switching functions, or occasionally when one output is left unterminated. In this latter case the relevant coarse attenuator should be switched to the 6-12 volt output position: in other cases, provided that the overload condition is of a temporary nature the indication can be ignored.

If the warning lamp continues to flash then an overload is present. This can be due to incompatible generator settings or load conditions causing a reduction of pulse amplitude by 5% or greater.

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PERIOD
1m
100µ
10µ
1µ
0·1µ
10m
100m
1s
10s
MIN
SECS
MAX
DELAY
200µ
20µ
2µ
0·2µ
0
2m
20m
200m
2s
MIN
SECS
MAX
WIDTH
200µ
20µ
2µ
0·2µ
·02µ
2m
20m
200m
2s
MIN
SECS
MAX
SUPPLY
THRESHOLD
MANUAL
+
−
RELEASE FOR NORM. SYNC
EXT MAN GATE -SLOPE
1KΩ 30pF
30V MAX
INPUT
SYNC. WIDTH
MAX
MIN
2V
INTO
50Ω
SYNC OUT
PG 75A
PULSE GENERATOR

FIG. 2-1 PG–75A FRONT PANEL

SECTION 3

FUNCTIONAL VERIFICATION

3.1. WARNING

(i) The instrument is intended for driving resistive loads at ground potential. The output protection circuits are calibrated to detect 10% changes in load resistance and for correct operation at maximum output close tolerance loads should be used.

(ii) The user is advised that the PG-75A is capable of delivering 50 watts continuous power on each channel and incautious use of controls will damage low power terminations (e.g. switching to Complement, increasing width or frequency etc). Please use terminations of sufficient power handling capability at all times.

3.2. The purpose of this section of the manual is to help the user during 'first time' operation of the instrument both in checking that no damage has occurred during transit and to help in becoming familiar with the action of the front panel controls. The equipment required for the checkout of the PG-75A is as follows:-

3.2.1. A general purpose oscilloscope of vertical bandwidth greater than 35 MHz, having double beam and external trigger facilities and having vertical signal delay.

3.2.2. One 50 ohm co-axial termination capable of 50W dissipation and one 50 ohm co-axial termination capable of 1/2W dissipation.

3.2.3. 2 BNC-BNC cables.

2 BNC-T connectors.

3.3. TEST CONNECTIONS AND SETTINGS

3.3.1. Connect the positive output socket via a 50 ohm cable to the 50W termination and T connectors at the oscilloscope vertical inputs. Switch negative attenuator to the 6-12 volt position.

3.3.2. Connect SYNC OUT via 50 ohm cable and terminated T-connector to the external trigger socket of the oscilloscope.

3.3.3. Connect power cable to mains supply.

BROWN	-	Live
BLUE	-	Neutral
YELLOW/GREEN	-	Earth

3.3.4. Set the instrument controls as follows:-

POWER	Off
FREQUENCY Vernier	10μs c/Clockwise
DELAY Vernier	0-0·2 μs c/Clockwise
WIDTH Vernier	0·02-0·2 μs Midway
GATE/SYNC/EXT	NORM/SYNC
SP/DP/SQ.WAVE	SP
NORMAL/COMPLEMENT	Normal
+ AMPLITUDE SWITCH	Maximum
- AMPLITUDE SWITCH	6-12V
VERNIERS	Clockwise
SYNC WIDTH	Clockwise

Set the oscilloscope sweep speed to 0·1 μs/cm and vertical sensitivity to 20V/Div DC coupled. Centre trace.

Proceed as follows:-

3.3.5. Pulse Output

Switch POWER on, check for the sound of cooling fan and note that pilot lamp lights. The unit requires approximately 3 minutes warming-up time during which the overload indicator may flash. A rectangular pulse approximately 50V amplitude and approximately 100 ns wide will appear on the screen. (The trigger controls of the oscilloscope may need adjustment).

Check AMPLITUDE control vernier, 50V maximum and a minimum of 25V on the 50V range.

Return AMPLITUDE vernier to clockwise position and check attenuator steps. Return to top range.

Repeat for negative output with positive output switched to a low amplitude.

N.B. Reduce pulse output amplitudes to 6-12 volts with verniers anti-clockwise for remaining tests. Increase oscilloscope sensitivity accordingly.

Switch to COMPLEMENT on both channels and note both pulses are inverted but remain at the same polarities with respect to ground. Return to NORMAL mode. The WIDTH control will need re-adjustment in COMPLEMENT, particularly when narrow widths (less than 100 ns) are used.

Turn pulse WIDTH vernier from one extreme to the other, note pulse width changes smoothly. Return vernier to midway position.

Turn DELAY vernier from one extreme to the other. Note pulse moves from left to right.

Depress UNDELAYED button and note that output is still present but delay control is inoperative.

Return DELAY control to counter clockwise position.

Turn PERIOD control clockwise and switch to 0·1-1 μs. Now turn PERIOD vernier c/clockwise until two pulses appear on the screen, one at each end.

3.3.6. Double Pulse Mode - Square Wave Mode

Switch to DP. Turn DELAY vernier clockwise until a second pulse appears after the first on the screen. Check that WIDTH vernier alters the width of all three pulses now on the screen. Now switch to SQ. WAVE and adjust oscilloscope time base and FREQUENCY vernier until one complete cycle appears. Check symmetry control SYM allows you to vary the mark to space ratio $\pm$7% of period approximately. Return to SP mode.

3.3.7. Manual Operation

Reset the instrument controls as follows:-

GATE/SYNC/EXT/MAN	EXT/MAN
DELAY Vernier	0-0·2 μs c/Clockwise
WIDTH Vernier	2 ms Midway
SLOPE	+VE
NORMAL/COMPLEMENT	NORMAL
SP/DP/SQ.WAVE	SP
AMPLITUDE	6-12V
VERNIERS	Anti-clockwise

Set oscilloscope time-base to 1 ms/cm and operate the MANUAL button. A single pulse will appear at each output whenever the MANUAL button is pressed. Note: It may be necessary to set THRESHOLD control for this test - set to OV approximately.

Set SLOPE to negative, a single pulse will appear whenever the MANUAL button is released.

3.3.8. External Trigger

For the next test a square wave source of approx. 2V amplitude is required (such as the oscilloscope calibrator output). With the PG-75A controls set as previously, apply a 1 kHz square wave of more than 1V peak amplitude to the input jack of the pulse generator. Adjust THRESHOLD control until instrument triggers from a +1 volt input signal.

Connect the oscilloscope external trigger socket to the square wave source using a 'T' connector. Adjust the oscilloscope for a stable display.

A pulse will appear at each output of the pulse generator which will shift one half of a calibrator period when the SLOPE switch is operated.

3.3.9. Gated Operation

Retain the set up of 3.3.8. Set the instrument controls as follows:-

FREQUENCY	1 ms
Vernier	c/Clockwise
DELAY	0-0·2 μs
Vernier	c/Clockwise
WIDTH	2 μs
Vernier	Clockwise
GATE/SYNC/EXT	GATE
SLOPE	+VE
SP/DP/SQ.WAVE	SP
SYNC WIDTH	Clockwise
AMPLITUDES	6-12 volts
Verniers	Anti-clockwise
NORMAL/COMPLEMENT	NORMAL

Apply a 1 kHz square wave of greater than 1V amplitude to the EXT input jack as in 3.3.8. A group of pulses will appear followed by a space. Group and space are interchangeable by the operation of the SLOPE switch.

Switch to SYNC mode and note that pulses are continuous. Select EXT and note that pulses are at the rate of external drive and that the FREQUENCY controls are inoperative.

SECTION 4

OPERATION

4.1. GENERAL PRECAUTIONS

The PG-75A will produce a maximum output of 50 volts into 50Ω i.e. up to 50 watts continuous from each output socket and for safe operation particular attention must be paid to the following:-

4.1.1. Type of Load

(a) If long duty cycles at high outputs are required loads of the correct power rating must be used, i.e. up to 50 watts resistive. Special attention is necessary when Normal/Complement switches are used. Complement operation should normally be used at duty cycles greater than 60%.

(b) It is essential that the termination be a good quality RESISTIVE load of value not less than 47Ω.

(c) Capacitive loads greater than 200pf total must be avoided at all times.

N.B. A single ended wire or coaxial lead with a broken screen can sometimes cause the load to appear as a large capacitive termination and sound coaxial connections are recommended for safe operation.

(d) Inductive loads must be avoided unless suitable impedance matching networks are used to prevent inverse voltage swings causing damage to the output transistors.

4.1.2. Connectors

Always use 50Ω coaxial conductors. Two such leads are provided with each instrument.

4.1.3. Unused Outputs

An unterminated output can appear to the overload detection circuit as an OVERLOAD condition and the warning lamp may flash. Similarly cross-talk can occur due to this apparent fault condition. To avoid these effects the coarse attenuator on the unused channel should be switched to the 6-12 volt position or lower.

4.1.4. Incompatible Settings

(a) Whenever the width and delay settings or combination of both exceeds the effective period available instability can occur giving incorrect pulse outputs and will under certain conditions cause the overload system to operate. Always check operational controls before suspecting a unit fault.

(b) A width setting of less than 30 ns will also appear as a fault condition if, due to rise time limitations, the output level pulls down by more than 10%. This will not occur during normal operation but if, for example, in Double Pulse mode, the Delay control is set less than the width, the second pulse will appear chopped and can cause an unstable condition. Similarly at high frequencies in Double Pulse, precise setting of both Width and Delay controls will be necessary to obtain a stable output.

4.2. OVERLOAD CONDITIONS

The overload circuit measures the approximate power dissipated in the output stage by detecting collector volts and emitter current and using these inputs at appropriate levels to operate the protection shut down device. Overload conditions and indications can be caused by incorrect loading or incorrect drive conditions as follows:-

(a) Incorrect loading can only be caused by using termination values less than the specified 50 ohms. The overload system is set to trip when the output transistor dissipation approaches 5 watts i.e. when the output voltage falls to 45 volts or lower due to incorrect termination (50 ohms-10%). Higher values of load will not trip the circuit but the output pulse shape will be degraded.

(b) Incorrect drive conditions can be caused by:

(i) Delay setting incompatible with Width generator in D.P. mode.

(ii) Delay and/or Width incompatible with main Period setting.

(iii) Width too narrow i.e. less than 30 ns.

(iv) Incorrect setting of internal gain preset.

4.3. OVERLOAD INDICATION

(a) The primary indication of overload is the lamp fitted between the two output channels, the lamp being driven from a monostable circuit triggered from the overload sensing system. The overload system is a self-resetting device and under continuous overload will produce a pulsed input to the indicator circuit causing the lamp to flash at approximately 1 second intervals. Overload conditions (i.e. 4.2.) can be simulated during switching operations e.g. Normal/Complement, but provided that the indication is temporary e.g. a single flash, they should be ignored.

4.4. VENTILATION

Under no circumstances must the ventilation holes be blocked or restricted and if for any reason the fan fails at 'switch on' or during operation then the instrument must be disconnected from the mains supply and the cause of failure rectified before re-using it.

4.5. OPERATING MODES

4.5.1. Repetitive Pulse

(a) Set Gate/Sync/Ext selector to NORMAL/SYNC.

(b) Set Frequency/Delay/Width control to approximate settings.

(c) With amplitude range switches in the 6-12 volt condition monitor the pulse output on a suitable oscilloscope.

(d) Set Function selectors for Single (SP) Double Pulse (DP) or Square Wave as required then:-

(i) Single Pulse Set Pulse Width to required setting using appropriate oscilloscope time base, then set Delay for required time interval between Sync Pulse and Output Pulse.

N.B. For short delays or pulse advance, it will be necessary to display the Sync output pulse on the alternate oscilloscope trace.

Finally set Amplitude to the required level with termination connected before connecting to the unit under test.

(ii) Double Pulse. Adjust Delay vernier to ensure that pulses are not coincident and adjust pulse width for the required pulse output. Reset Delay vernier for correct inter pulse spacing and finally, set Amplitude to required level before connecting to the unit under test.

(iii) Square Wave. In this mode both Delay and Width verniers are inoperative and it is only necessary to set the Frequency to the required point before adjusting the Amplitude and connecting to the unit under test.

4.5.2. Synchronised Repetitive Pulse

The operation is similar to that outlined in 4.5.1. but the synchronising signal is first connected to the Sync input socket and frequency vernier adjusted for a synchronised output waveform.

4.5.3. Gated Pulse

Set Gate/Sync/Ext selector to the Sync condition and adjust pulse generator controls for the required ungated pulse parameters. On completion select the Gate condition and check for a gated output waveform.

N.B. The Slope switch and Threshold controls will allow full control of the gating function i.e. Gate On or Gate Off operation.

4.5.4. Repetitive Pulse (External)

Set up pulse generator as for internal operation then set selector switch to EXT. Connect external trigger source to the SYNC IN socket and note output pulse is present on oscilloscope before connecting to the unit under test.

N.B. The Threshold trimmer controls the trigger point of all external inputs and is normally set at or near 0 volts. Adjust as necessary.

4.5.5. Single Pulse (Manual)

Set up pulse generator and monitor oscilloscope as for normal repetitive pulse operation then switch to EXT. The manual button may now be used to trigger the pulse generator.

N. B. Some care is required with oscilloscope trigger level and the pulse generator Threshold must be set at OV for correct Manual operation.

4.5.6. Normal/Complement

For Complementary operation set NORMAL/COMPLEMENT switches to COMP.

N. B. EXTREME CAUTION IS REQUIRED IN COMPLEMENT OPERATION DUE TO THE POSSIBLE INSTANTANEOUS CHANGE OF AVAILABLE OUTPUT POWER e.g. a 0·5 watt mean output power in NORMAL can be 49·5 watts mean in COMPLEMENT at maximum amplitude setting. Always check the termination power rating before using Complementary operation or long duty cycles in NORMAL.

4.5.7. Current Output

The PG-75A is capable of driving 1 amp into 50 ohms and this can be utilised for current mode operation by padding the external load with suitable matching resistors e.g. a load or device under test with a Zo of 10 ohms could be driven via a 40 ohm series resistor of appropriate power level. Care should be taken to ensure that the total load is resistive with no significant reactive components.

SECTION 5

CIRCUIT DESCRIPTION

For ease of construction and maintenance the bulk of the electronic circuits of the PG-75A are mounted on three printed circuit cards, comprising respectively the timing circuits, ouput circuits, and power supply regulators.

5.1. Input Circuit and Rate Generator (Fig. 7-1)

The input and rate generating section consists of a Schmitt trigger and free-running multivibrator which are used to provide the basic pulse or square waves required to drive the width/delay section. When the instrument is operated in its External mode, the input frequency fed via the Schmitt circuit determines the rate of operation of the generator.

If the Gate or Sync mode is selected, the free running multivibrator determines the repetition rate, which can be 'pulled' by an external input (if present) in the sync mode and 'interrupted' in the Gate mode. The rate generating circuitry is housed on card 75/1 and provides four outputs, comprising a square wave derived directly from the free-running multivibrator with symmetry adjustment, and three further outputs which are used to drive the width, delay and sync pulse generators. One of these outputs may be inhibited by operating the Single/Double pulse selector so that the width generator can be driven either once or twice during each clock period.

Referring to the circuit diagram Fig. 7-1 Q1 to Q3 form the external input amplifier and Schmitt trigger, the input signals being applied to pin 1. D1 and D2 act as input protection clamps. The manual control push button operates into pin 2 and its position in the circuit gives the system a manual gate facility as well as single shot operation. Threshold may be adjusted between $\pm$2V and sensitivity is fixed at greater than 1V peak.

Q4 and Q5 form the slope selection inverters and their outputs are routed via the selector to either the rate generator iteself when SYNC or GATE modes are selected or to the output drivers when 'EXT' is selected.

Q6, Q7, and Q12, Q13 form the rate generator, Q9 and Q10 being variable current sources providing vernier control in the pulse mode and symmetry adjustment for square wave operation. Transistor Q8 is controlled such that it enables the clock either for the duration of a differentiated Schmitt trigger output during Sync operation, or for the duration of the gating waveform when the Gate mode of operation is selected.

(i) Negative output and Protection circuit.

(ii) Positive Output and Protection circuit.

(iii) Common overload and Indicator circuit.

5.3.1. Negative Output and Protection Circuit

(i) Normal/Complement

The input signal on P1 is applied to phase splitter Q2, Q3 via emitter follower Q1, to produce the normal or complemented versions of the input signal. The phase required (e.g. Normal) is selected by connecting P3 to the +15 volt rail. This raises Q3 collector to a higher potential than that on Q2 collector. D4 is biassed off and the waveform at Q2c is applied to the base of Q5.

(ii) Level Shift

Q5 and Q6 conduct when Q5 base is 2 x Vbe, or more, positive with respect ot Q6 base and the current flowing in R24 provides the source voltage for the push pull driver stage Q7, Q8. The negative excursion of the pulse is clipped by Q6 turning off and this level (i.e. maximum drive) is adjustable by RV1. R19 in Q6 collector reduces the total dissipation in the transistor.

Driver

Complementary emitter followers Q7 and Q8 provide a low impedance source to drive the transient base and collector capacitance currents of the output transistor Q9.

Output Stage

The output stage proper is a single RF Power transistor Q9/2N3632, (Q109/2N5161) which carries a large fingered heatsink and is placed directly in the air flow of the cooling fan. Q9 base is driven sufficiently positive for the transistor to saturate but the degree of saturation is controlled by the conduction of D8, which by-passes excess current from Q6 into the collector of Q9. This reduces the degree of saturation to a point where the pulse top is still clean but turn-off delay is kept to a minimum. The optimum saturation point may vary with different output transistors and some adjustment may be made by shorting out diode D6 and/or D7. C9 improves transit times by reducing the emitter impedance to fast transients. D9, D10, reduce overshoots on the positive edge.

Amplitude Control

Amplitude control and tracking is achieved by variation of the -55 volt rail and current drive to the input phase splitter.

This control allows the output voltage to be reduced to less than half by reducing the power supply voltage at P8. However, as this voltage is reduced Q9 requires less base drive voltage to maintain the required degree of saturation and hence preserve the pulse shape of narrow or high frequency wave forms. This reduction of drive is achieved by "tracking" the voltage at P5 in sympathy with the power supply voltages causing a corresponding reduction in Q4 collector current and the drive to Q6.

The power supply variation (Fig. 7-4) is controlled by the amplitude vernier RV6 and the drive current by the potentiometer network R44, RV7, R45 and R3 (output board).

Output Protection

In normal operation, when Q9 is driven into conduction, it quickly saturates and the dissipation is low but under short circuit or overload conditions Q9 collector current may be insufficient to cause saturation and the power level (collector volts vs emitter current) in Q9 may become excessive. The protection circuit is designed to detect this combination of current and voltage and to turn off the drive current through Q6 when the levels exceed preset limits (approximately 5 watts).

Q12 and its associated network D13, D14, D15, D17 and level shifter D16 provide a detector circuit such that, when the cathode voltages of D15 and D17 are both more than 0·5 volts above the negative rail Q12 will turn on.

When Q12 conducts, monostable Q10, Q11 operates with Q10 turning on, pulling Q5 base down to -15 volts and hence turning off Q6. Q13 provides a quick recovery path for C13 and also prevents the negative going excursion on Q10 base to ensure that Q10 can conduct and protection operate, whatever the state of charge of C13.

Power Limit Design Parameters

In order to provide a sufficient margin of safety on the power handling capability of the output transistor the steady state dissipation has been limited to 5 watts as follows.

The 0·5 volt trip levels at the cathodes of D15, D17 correspond to a collector to negative rail voltage of 10 volts and an emitter current of 0·1 amp.

The equivalent maximum permissible dissipations with a collector to rail voltage of 10 volts and emitter resistor of 5 ohms are given by

$$\frac{1}{4} \times \frac{10^2}{5} = 5 \text{ watts over load}$$

and

$$0{\cdot}1\text{A} \times 50\text{V} = 5 \text{ watts short circuit}$$

The ability to drive overloads without the protection operating depends on the overdrive available through Q6 and whether this is sufficient to allow Q9 to reach saturation at a higher current and with greater than the normal 5 volts across the emitter resistor.

5.3.2. Positive Output and Protection

The positive channel may be considered identical as far as the operation is concerned and that only the supply polarities and device types Q101-Q109 inclusive are different.

5.3.3. Overload Indicator Circuit

When Q10 conducts, the current through R40 triggers the lamp flasher monostable IC1, or, if the current is continuous, converts it into an astable multivibrator.

If the positive channel is simultaneously subjected to an overload, causing current to flow in R140, the flasher circuit will be continuously energised and the lamp will remain ON.

5.4. Power Supplies (Fig. 7-6)

The power supplies are conventional circuits with low power supplies mounted on the printed circuit board and high power regulators mounted on two heat sinks in the air flow of the main cooling fan.

The printed circuit card hinges out for ease of maintenance and provides access to the main reservoir capacitors. The complete power supply consists of seven separate circuits as follows:-

(i) +55 volts (variable)
(ii) -55 volts (variable)
(iii) +15 volts (fixed)
(iv) -15 volts (variable)
(v) +12 volts (fixed)
(vi) +7 volts (fixed)
(vii) -7 volts (fixed)

5.4.1. +55 Volts

This is the high voltage supply for the positive output stage and is supplied from the 62 volt rms transformer secondary winding and bridge rectifier MR13-MR16. Primary regulation is provided by regulator OP1 with its current source Q7. D7 provides the reference level for OP1 and RV2 presets the output voltage at P29 to the correct level. OP1 provides the regulated drive to Q8 and series pass transistor Q9. Output current fold back is provided via R24, D8 to give the power supply a limited protection capability. Pin 5 of the regulator is connected via P30 to the output amplitude vernier which varies the D.C. output voltage over the range 30 to 55 volts. A second output is taken via P32 to the output circuit to provide the tracking control for the input amplifier. RV4 is adjusted for optimum pulse shape with the amplitude vernier at minimum.

N. B. If for any reason this supply fails, remove the main positive pulse output transistor 2N5161 before carrying out the repair. Do NOT replace the transistor until the D. C. regulates correctly at +55 to +57 volts.

-55 Volt Supply

This is essentially the same circuit as the positive supply except that the secondary supply is lower at 57 volts rms and an additional transistor Q11 is fitted to provide fold back current limiting to Q12 base. The current limit is preset to operate at approximately 2 amps. RV5 is adjusted for D. C. output volts and RV7 is the output stage tracking preset.

N. B. It for any reason this supply fails, remove the main negative pulse output amplifier 2N3632 before carrying out the repair. Do NOT replace the transistor until the D. C. regulates correctly at -55 to -57 volts.

+15 Volt and +7 Volt

These rails are used to provide +Vcc for the timing circuits and Output stage driver circuits. A nominal 20 volt rms secondary feeds the rectifier bridge MR5-MR8 and two regulator circuits RL2 and Q1 etc. RL2 is a TO3 style encapsulated regulator supplying +15 volts to P44 and the tag strip mounted on the right hand side frame.

Q1 is mounted on a separate heat sink assembly and is a conventional series regulator for the +7 volt rail at TS2/3.

-15 Volt and -7 Volt

Both supplies are used for the timing and output driver circuits and are fed from rectifiers MR9-MR12. Q6 is the main 15 volt regulator with control and protection circuits provided by Q4, Q5 and Q3. RV1 presets the base drive of Q4 and allows the -15 volt rail to be set for correct working level. Q2 is supplied from the raw D. C. supply at P41 and provides series regulation for the -7 volt rail at TS2/4. Q2 is mounted on the main heat sink fitted on the chassis centre member.

+12 Volts

MR1-MR4 supply approximately 20 volts raw D. C. to solid state regulator RL1 to provide +12 volts D. C. for the width/delay circuits via TS2/2.

SECTION 6

MAINTENANCE

6.1. Warranty

Lyons Instruments Limited guarantees each instrument manufactured by us to be free from defects in material and workmanship for a period of one year from date of delivery to the original purchaser. Repair during this time will be made by us free of charge if the instrument is returned to our works carriage paid.

Excluded from this guarantee is all damage caused by, or related to, abuse of the instrument either electrically or mechanically. In this case repairs will be charged at cost and an estimate will be submitted for approval before the work is started. Output transistor replacement if required is not normally included in the terms of the guarantee.

If an instrument is believed to be defective, please notify our Service Department, giving the model and serial number of the instrument, as well as a description of the nature of the fault. The Service Department will then, if necessary authorise the return of the instrument under the terms of this guarantee and advise how shipment should be made.

6.1.1. Claim for damage in shipment

If, on receipt, the shipping cartons show evidence of rough treatment, entry should be made on the carrier's delivery receipt indicating this condition.

As each instrument is unpacked, it should be inspected to ascertain that no damage has occurred during shipment. If no damage is visible, operational checks should be performed to make sure that the instrument is in its original operating condition. If any damage is revealed, a claim should be filed immediately with the carrier, stating the extent of the damage. A copy of this report should be forwarded to Lyons Instruments together with the model and serial number of the instrument. We will then advise how the instrument should be returned for repair or replacement.

6.1.2. Shipping instructions for returning instruments under guarantee

No instrument should be returned to the factory without prior authorisation from Lyons Instruments Limited

Shipping instructions will be given at the time the return of an instrument is authorised. In all cases the instrument should be packed in a strong container and surrounded by adequate shock-absorbing material.

Transit insurance covering the instruments being returned to Lyons Instruments should be effected by the sender.

6.2. Routine Maintenance

The PG-75A is fan cooled and when used in dusty environments the air intake must be checked at regular intervals to ensure adequate air flow. In very hot conditions, the fan motor may require oil at 12 monthly intervals, remove instrument top cover and place no more than two drops of light oil on to the bearing inner sponge.

WARNING - ACCIDENTS WILL HAPPEN

FOR THESE TESTS 50 OHM LOADS WITH AN ACCURACY OF ±2% AND POWER RATING FOR 50 WATTS ARE NECESSARY. LOW POWER LOADS MAY ONLY BE USED WITH REDUCED GENERATOR DUTY CYCLES AND THEN AT THE USER'S RISK.

6.3. Calibration

The PG-75A has been designed to have a minimum of internal adjustments. The frequency, width and delay controls have ranges considerably in excess of the 10 to 1 requirements and therefore there is no need for upper and lower limit range settings. The remaining potentiometers are concerned with power supply settings and output stage 'on' currents and should require adjustment at twelve monthly intervals or after any necessary repair work. Details of the adjustments are as follows, but output stage adjustments should not be made unless known 50 ohm ±2% loads are available. Damage caused by incorrect adjustment is not included in the warranty terms.

6.3.1. Power Supplies

Note:- If complete recalibration or adjustment/repair of the 55 volt supplies is necessary REMOVE BOTH PULSE OUTPUT TRANSISTORS TO AVOID DAMAGE DUE TO INCORRECT ADJUSTMENTS.

Before attempting to adjust any power supply check the voltages against Table 1 making adjustments only as necessary. All voltages can be measured with respect to chassis at the tag strips on the side frames.

A faulty 55 volt supply is normally indicated by a reading of 70 volts or greater. If this condition exists switch off immediately and remove the output transistors before making further tests.

Set NORM/COMP switches to COMPLEMENT on both channels, select EXT on the mode switch and check voltages as follows:-

N. B. Turn both amplitude verniers to maximum.

Supply	Test Point	Reading	Adjust	P-P Ripple
+55V	TS1/1	+57V/$\pm$5%	RV2	Less than 50mV
-55V	TS1/2	-57V/$\pm$5%	RV5	Less than 50mV
+15V	TS1/3	+15V/$\pm$5%	NIL	10mV
-15V	TS1/4	-15V/$\pm$5%	RV1	10mV
+12V	TS2/2	+12V/$\pm$5%	NIL	10mV
+7V	TS2/3	+7V/$\pm$0·5V	NIL	5mV
-7V	TS2/4	-7V/$\pm$0·5V	NIL	5mV

TABLE 6.1.

6.3.2. TIMING CIRCUITS

No calibration controls are fitted in the timing circuitry, and it should not normally be necessary to recalibrate this section of the PG-75A unless a breakdown has occurred. All ranges, frequency width and delay are arranged to have sufficient overlap to allow any component to be replaced when necessary.

If a breakdown has occurred a logical check of strategic points throughout the circuit should be carried out to isolate the faulty circuit.

Table 6.2. will assist the location of any defective stages.

6.3.3. OUTPUT CIRCUITS

Before making adjustments to the output stage refer to section 6.3.4.

Two essentially similar output circuits are mounted on the output printed circuit board. The board is supported on hinge brackets to allow easy access for servicing. Each circuit consists of the output amplifier and its power monitoring circuit. Breakdown faults are easily located with the aid of a 50 MHz oscilloscope but great care must be exercised when recalibrating the drive levels to the output transistor especially after replacement of any active device in the circuit. A detailed setting up procedure is given under 6.3.4. and this must be rigidly followed to prevent accidental damage to transistors. The overload system may be checked for correct operation by following the procedure 6.3.4. sub para 8 and 9.

6.3.3. Defect Symptons	Test For:	Investigate if Test unsatisfactory
No positive pulse	(1) +55V supply (2) +7V pulse at Q9B	+55V power supply Output Stage Q1-Q9 inclusive
No negative pulse	(1) -55V supply (2) -7V pulse at Q109b	-55V power supply Output stage Q101-Q109 inclusive
Both pulse outputs defective	(1) Sync Output	Clock circuit Q19, Q6-Q16 inclusive and function switch
	(2) Output on Square Wave	Clock circuit Q18, Q6-Q16 inclusive and function switch
	(3) Delay output at Q109c	Delay Circuit Q101-Q109 inclusive
	(4) Width output at Q116c	Width Circuit Q110-Q116 inclusive
No undelayed pulse on DP	(1) Undelayed operation	Q17 Clock Circuit
Outputs satisfactory but no sync output	(1) +2V sync output	Q117-Q122 Sync Circuit inclusive
No outputs in External/Gate modes	(1) Correct setting	Q1-Q5 Clock Circuit inclusive

TABLE 6.2.

6.3.4. OUTPUT STAGE SETTING UP PROCEDURE

General. The following procedure must be followed step by step when calibrating or carrying out repair work on PG-75A output stages. It will also help in locating faults in the circuit, but if any doubt exists please contact the factory.

Note: Figures in parenthesis are for positive channel.

(1) Ensure the mains power is off.
Remove 4 plug in transistors Q6, Q9 (negative) Q106 Q109 (positive). It will be necessary to first desolder the captive lead on the base of Q6, (Q106) and release the securing screws on Q9 (Q109) heat sinks. Transistors or heat sinks must be marked on removal to ensure that they are replaced in their correct positions.

(2) Switch on mains power and monitor the raw D. C. supplies at the power supply printed circuit board. These should read:-

P16 +90 volts nominal
P22 -80 volts nominal

(3) Turn both amplitude verniers (front panel) fully clockwise and adjust power supply presets RV2 and RV5 for +57V and -57V respectively.

(4) Switch pulse mode switch to Square Wave, set period to approximately 1 MHz, and check the input waveform at P1 (P101) of the output board. This waveform should be a square wave of amplitude approximately $\pm$2 volts and symmetrical about 0 volts.

(5) Monitor waveform at Q5b (Q105b) and check for a square waveform switching between -9 (+9) volts and -13 (+13) volts. Verify operation in both Normal and Complement. Plug in Q6 (Q106).

(6) Monitor the square waveform on R24 (R124) i.e. base Q7, Q8 (Q107 Q108) adjust RV1 (RV101) for 8 volts amplitude.

(7) Connect a 150Ω $\frac{1}{2}$W carbon resistor between Q9b (Q109b) and -55V (+55V) rail and verify waveform on Q9b (Q109b) is 7·2 volts amplitude. Remove 150Ω resistor and connect a 1K2 $\frac{1}{2}$ watt resistor from Q9b (Q109b) to 0 volts. Recheck the waveform at Q9b (Q109b). Any loss of waveshape in these two checks indicates a faulty Q8 or Q7 respectively.

(8) Set front panel amplitude verniers to minimum, switch off power and plug in Q9 (Q109). Switch power on, and with oscilloscope and period vernier adjusted to display a waveform of approximately 10μs period, connect output connector, suitably terminated, to the oscilloscope. Verify that the output waveform is present at approximately 25 volts amplitude.

(9) Turn amplitude vernier to maximum and adjust oscilloscope sensitivity for a 5 cm high display.

Adjust RV1 (RV101) slowly to bring the output transistor out of saturation (shown by a reduction in output amplitude and an increase in pulse top aberrations). The output protection circuits must be seen to operate before amplitude has decreased by 10 volts. Reset RV1 to just cause the output transistor to saturate.

(10) With pulse generator set to 1 MHz repetition rate investigate pulse top for high frequency oscillations. If these exist short out D6 and/or D7 (D106/D107).

(11) Reduce amplitude vernier to minimum and adjust RV7 (RV4) on the power supply board until the output waveform is just in saturation.

(12) Set amplitude vernier to maximum and shunt the 50Ω load with a 390Ω resistor. Adjust RV1 (RV101) so that output drive is just sufficient to reduce perturbations on pulse top to approximately 10% peak to peak. Remove 390Ω resistor.

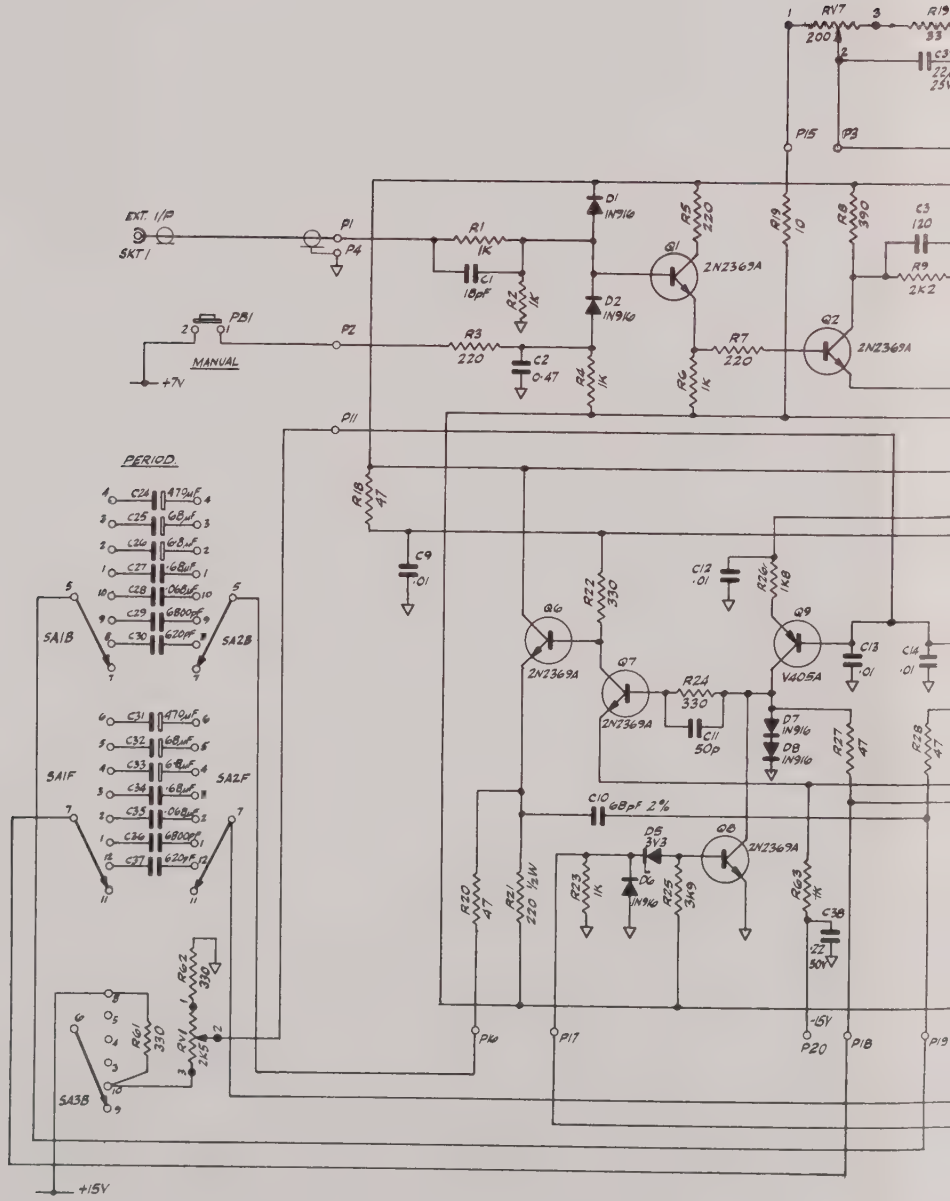
(13) Check for pulse generator operation without overload at 10 MHz repetition rate.

(14) On completion secure transistors Q6 (Q106) and Q9 (Q109) and check operation of pulse generator under all operating modes.

SECTION 7

DIAGRAMS

FIG 7-1	Clock Circuit Diagram
FIG 7-2	Width/Delay Circuit Diagram
FIG 7-3	Clock and Width/Delay Component Layout
FIG 7-4	Output Board Circuit Diagram
FIG 7-5	Output Board Component Layout
FIG 7-6	Power Supply Circuit Diagram
FIG 7-7	Power Supply Component Layout


EXT. I/P
SKT 1
P1
P4
R1
1K
C1
18pF
R2
1K
D1
IN916
D2
IN916
R5
220
Q1
2N2369A
R8
10
R8
390
C3
120
R9
2K2
PB1
MANUAL
+7V
P2
R3
220
C2
0·47
R4
1K
R6
1K
R7
220
Q2
2N2369A
P11
RV7
200
R19
33
P15
P3
PERIOD.
C24
470uF
C25
68uF
C26
68uF
C27
68uF
C28
·068uF
C29
6800pF
C30
620pF
SA1B
SA2B
C31
470uF
C32
68uF
C33
68uF
C34
·68uF
C35
·068uF
C36
6800pF
C37
620pF
SA1F
SA2F
R62
330
RV1
2K5
R61
330
SA3B
+15V
R18
47
C9
·01
C12
·01
R26
1K8
Q6
2N2369A
R22
330
Q7
2N2369A
R24
330
C11
50p
Q9
V405A
C13
·01
C14
·01
D7
IN916
D8
IN916
R27
47
R28
47
C10
68pF 2%
D8
3V3
D6
IN916
Q8
2N2369A
R20
47
R21
220 ½W
R23
1K
R25
3K9
R63
1K
C38
·22
50V
P16
P17
-15V
P20
P18
P19

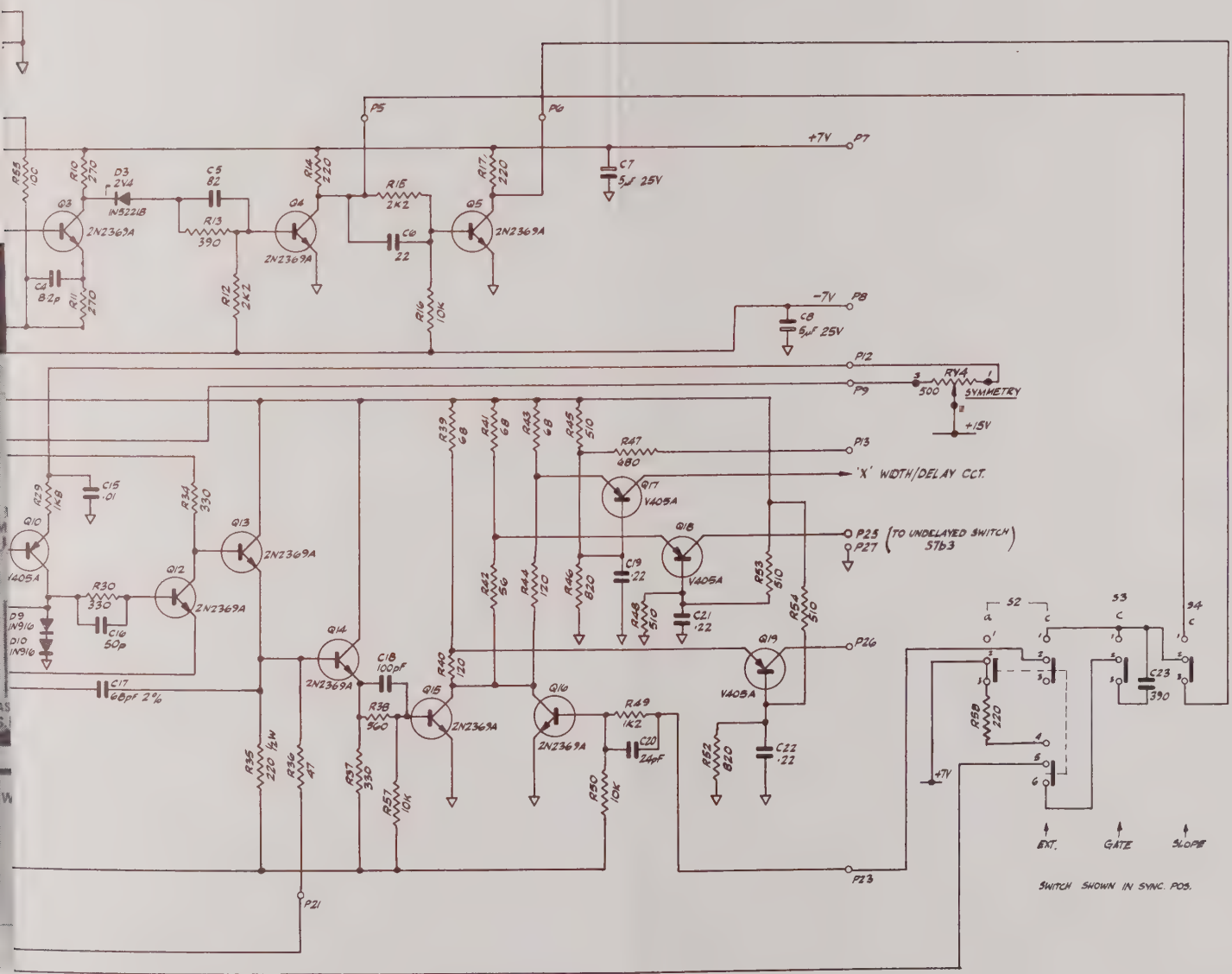
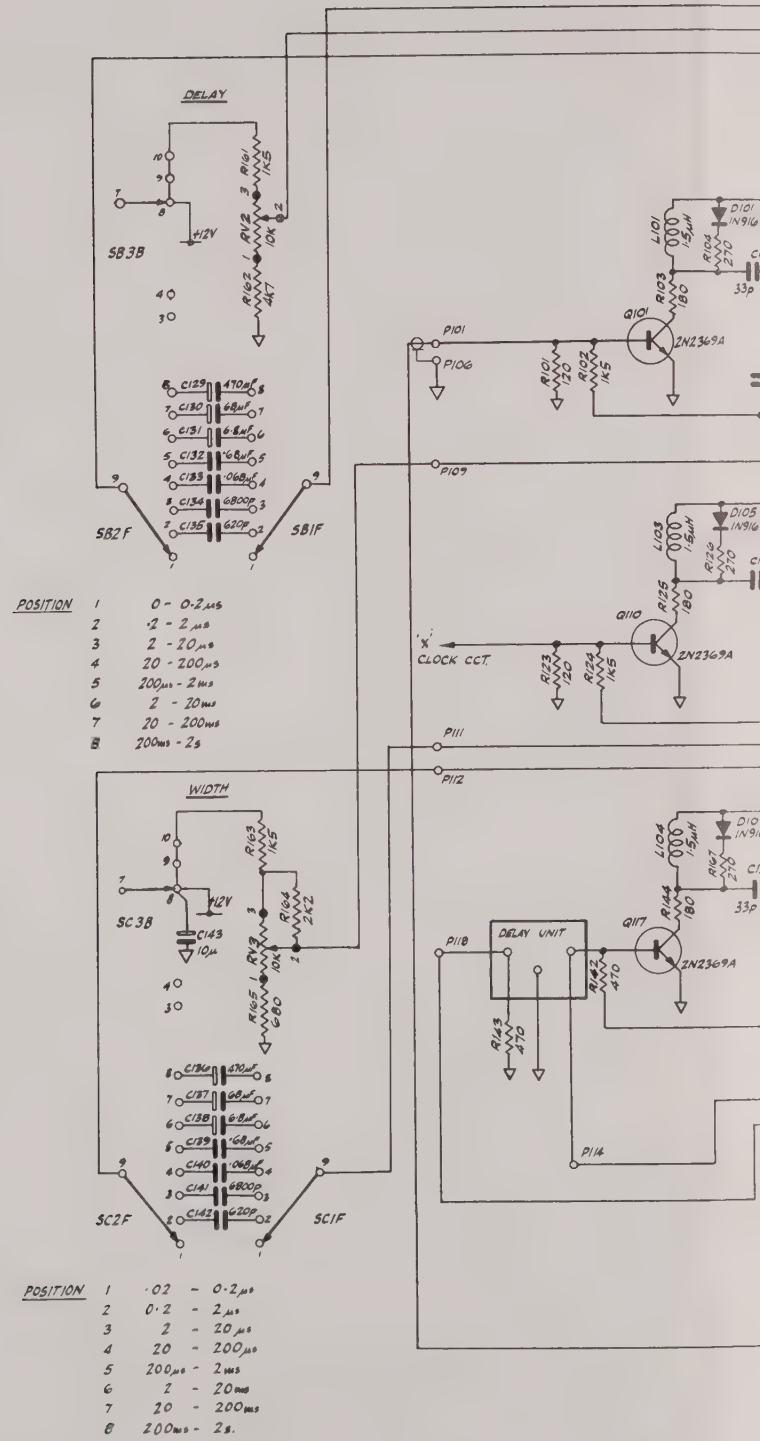


FIG. 7-1 CLOCK CIRCUIT DIAGRAM


DELAY
SB3B
+12V
RV2
10K
R161
1K5
R162
47
C129 470nF
C130 68nF
C131 6·8nF
C132 ·68nF
C133 ·068nF
C134 6800P
C135 620P
SB2F
SB1F
POSITION 1 0 - 0·2 mS
2 ·2 - 2 mS
3 2 - 20 mS
4 20 - 200 mS
5 200 mS - 2 mS
6 2 - 20 mS
7 20 - 200 mS
8 200 mS - 2 S
WIDTH
SC3B
+12V
C143 10µ
RV3 10K
R163 1K5
R164 2K2
R165 680
C136 470nF
C137 68nF
C138 6·8nF
C139 ·68nF
C140 ·068nF
C141 6800P
C142 620P
SC2F
SC1F
POSITION 1 ·02 - 0·2 µS
2 0·2 - 2 µS
3 2 - 20 µS
4 20 - 200 µS
5 200 µS - 2 mS
6 2 - 20 mS
7 20 - 200 mS
8 200 mS - 2 S.
L101 1·5µH
D101 IN916
R104 270
33p
R103 180
Q101 2N2369A
P101
P106
R101 120
R102 1K5
P109
L103 1·5µH
D105 IN916
R124 270
R125 180
Q110 2N2369A
'X' CLOCK CCT.
R123 120
R124 1K5
P111
P112
L104 1·5µH
D10 IN91
R127 270
R128 180
Q117 2N2369A
33p
P118
DELAY UNIT
R142 470
R143 470
P114

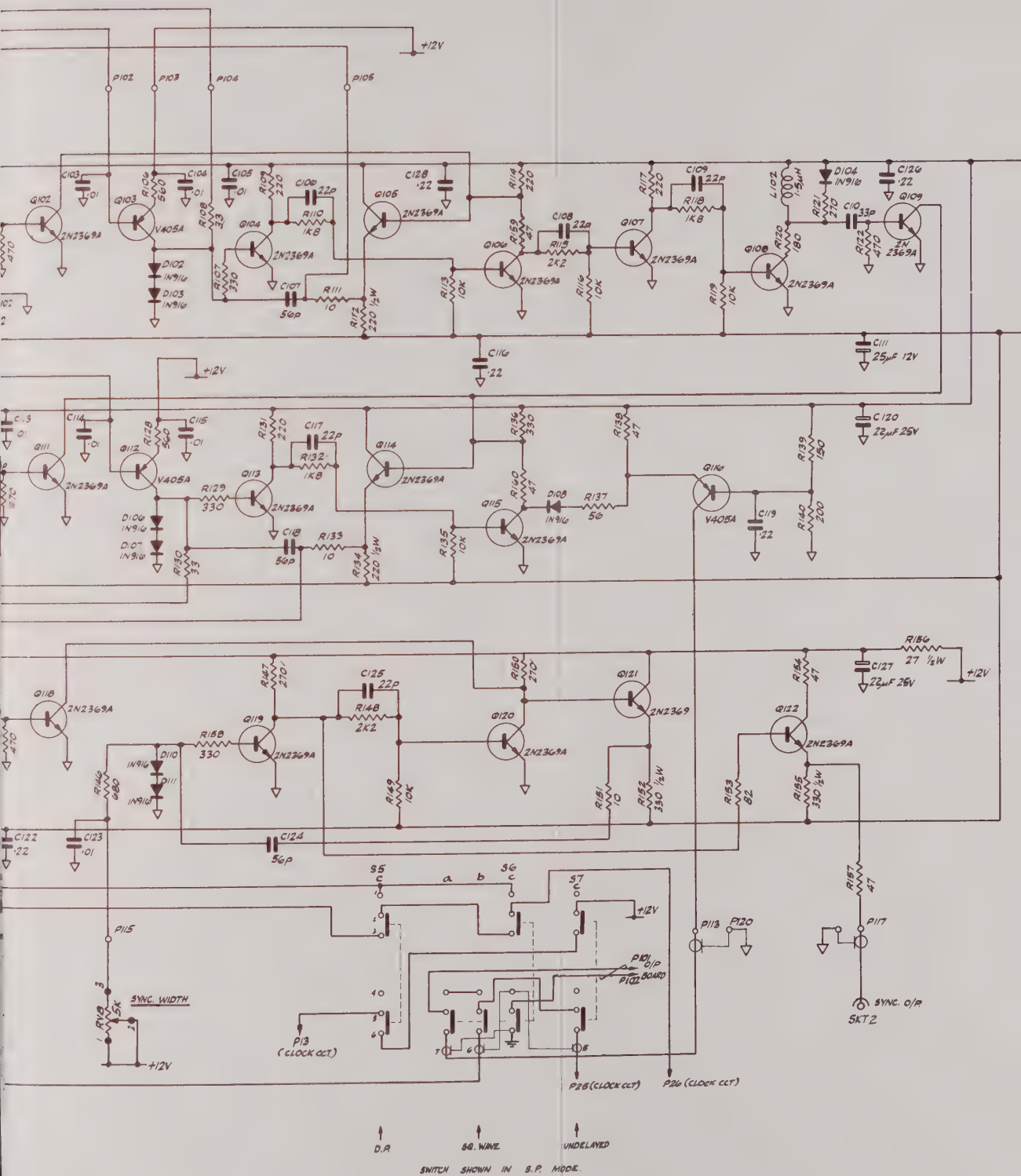


FIG. 7-2 WIDTH/DELAY CIRCUIT DIAG

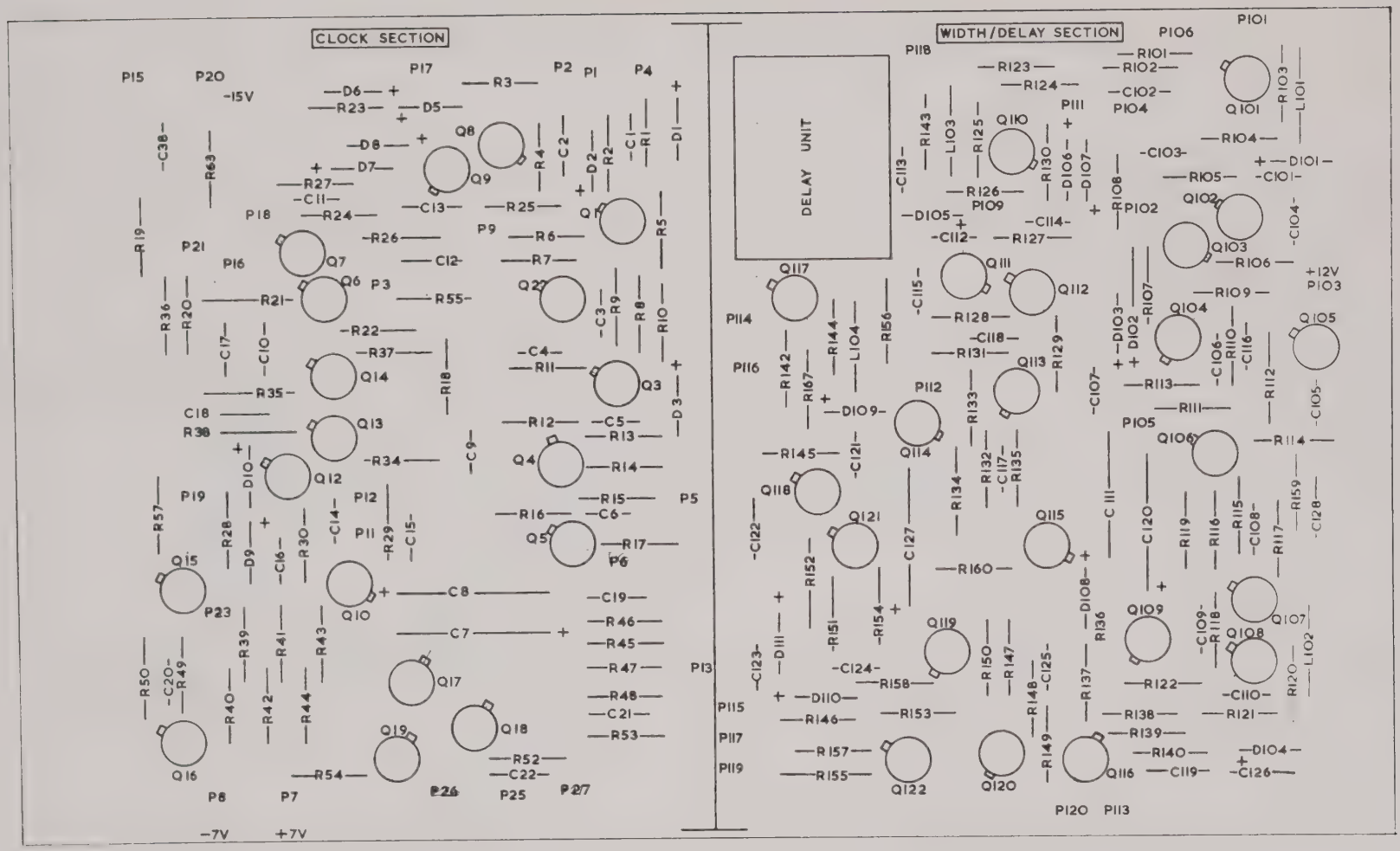
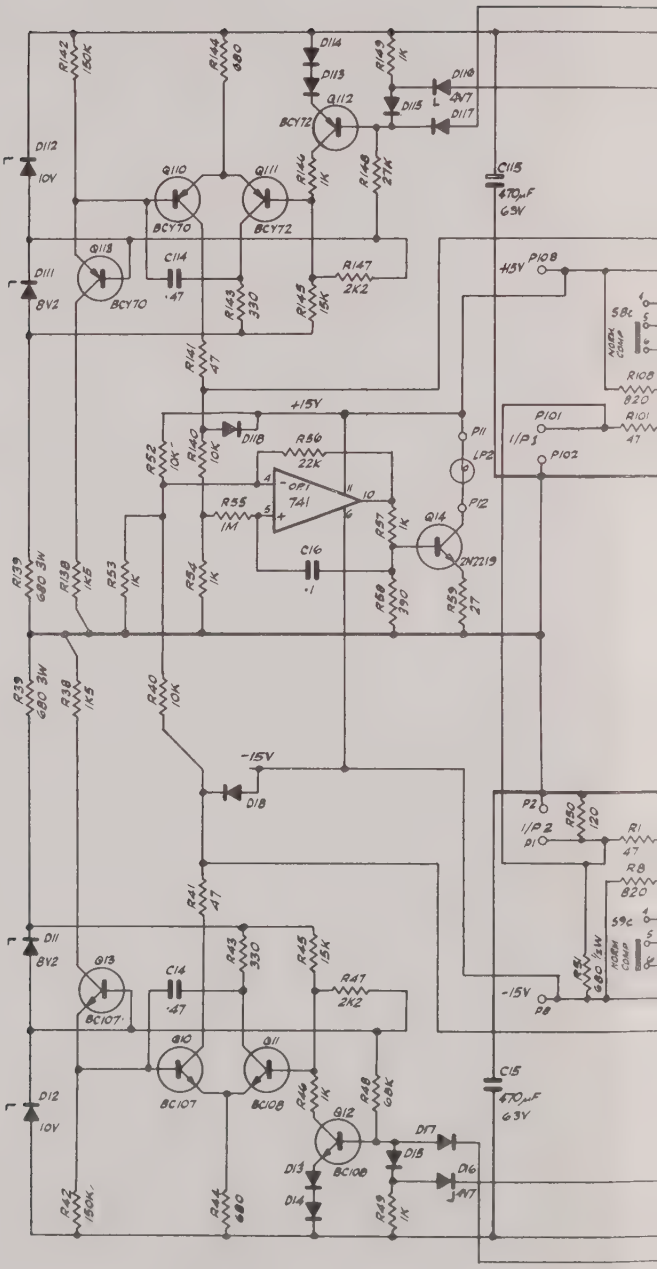
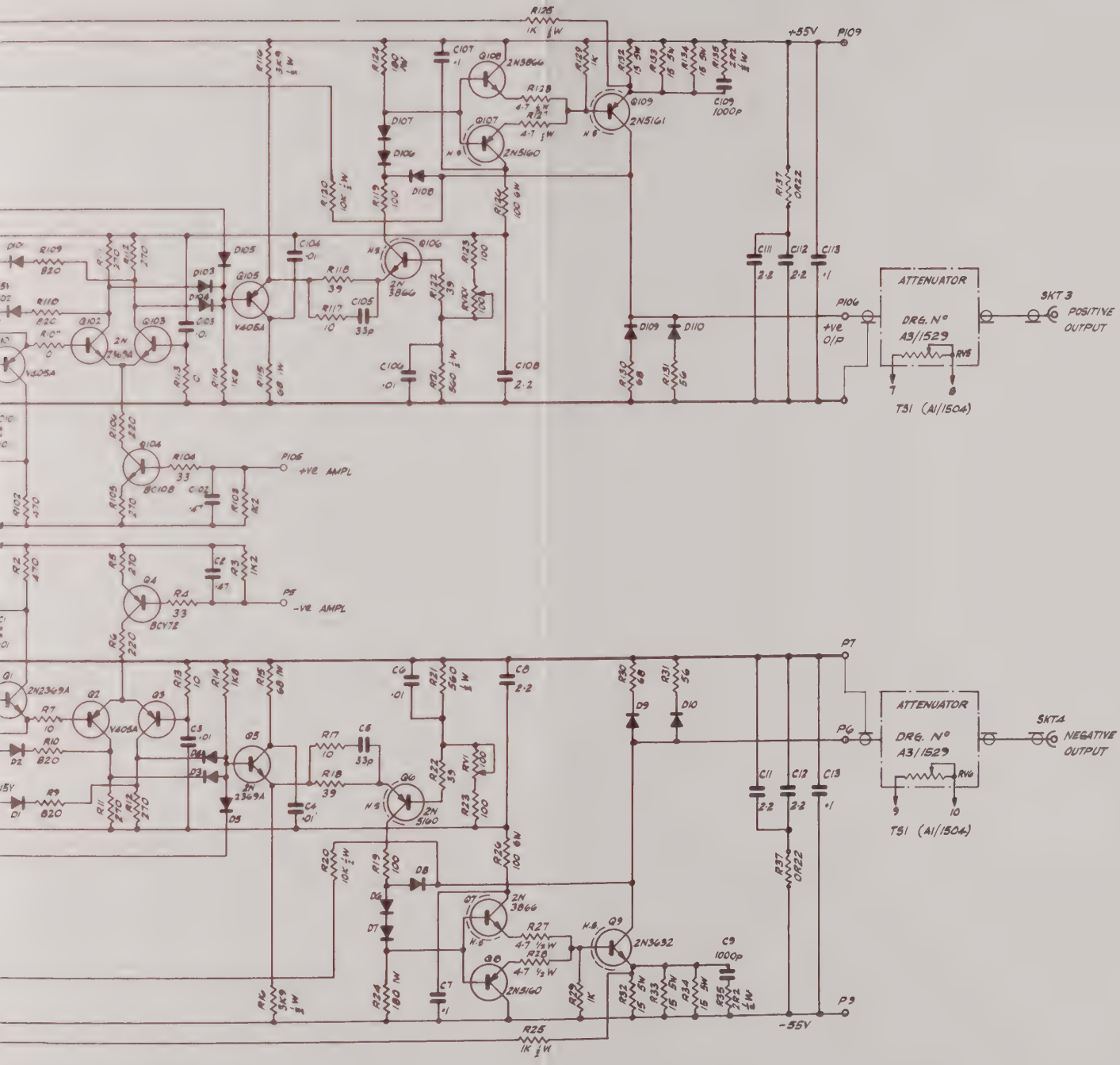


FIG. 7-3 CLOCK & WIDTH/DELAY COMPONENT LAYOUT



NOTE:
ALL RESIST
ALL CAPACI
ALL DIODE



LUES IN OHMS UNLESS OTHERWISE STATED.
LUES IN µF " " "
RE IN °K " " "

FIG. 7-4 OUTPUT BOARD CIRCUIT DIAGRAM

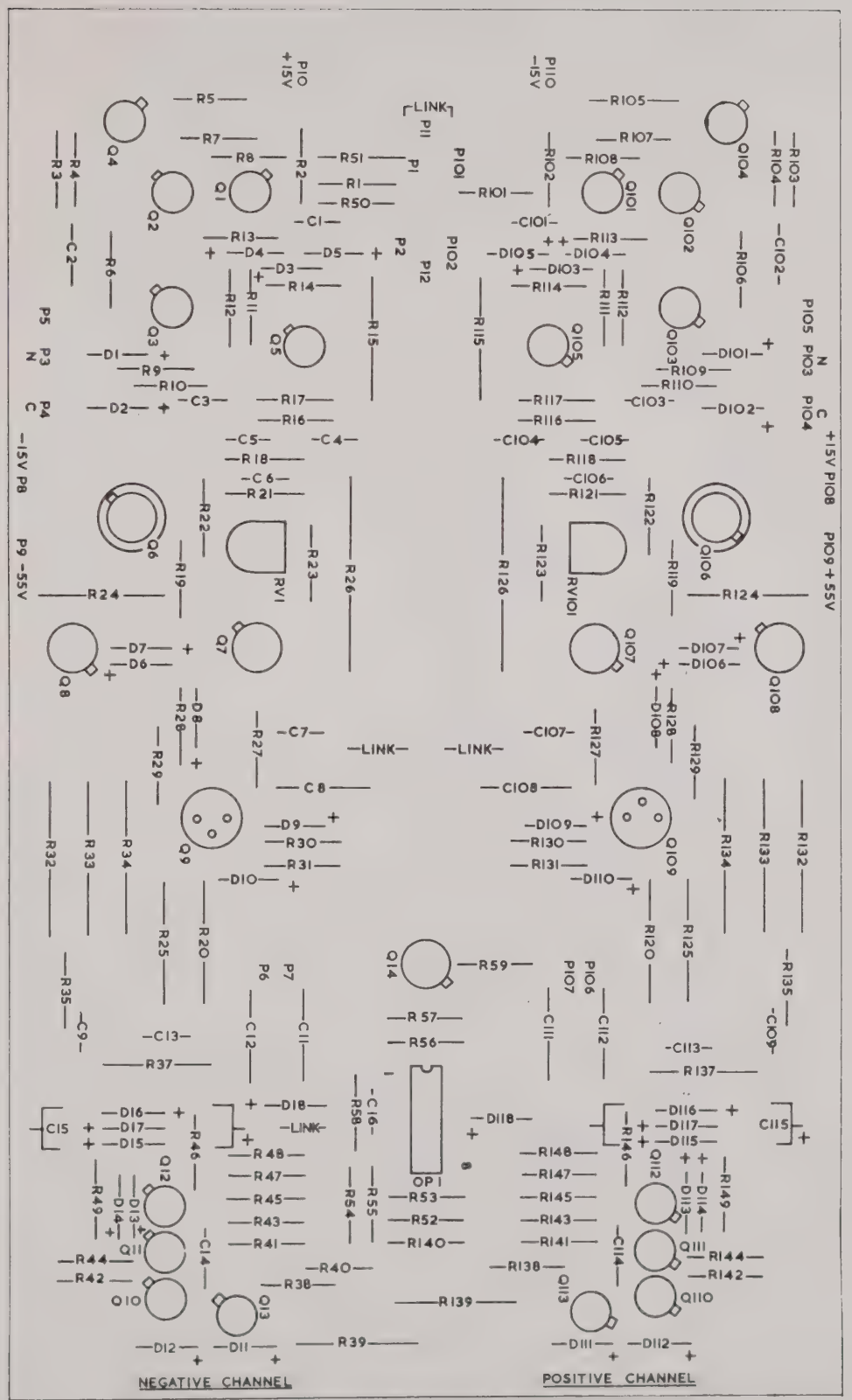
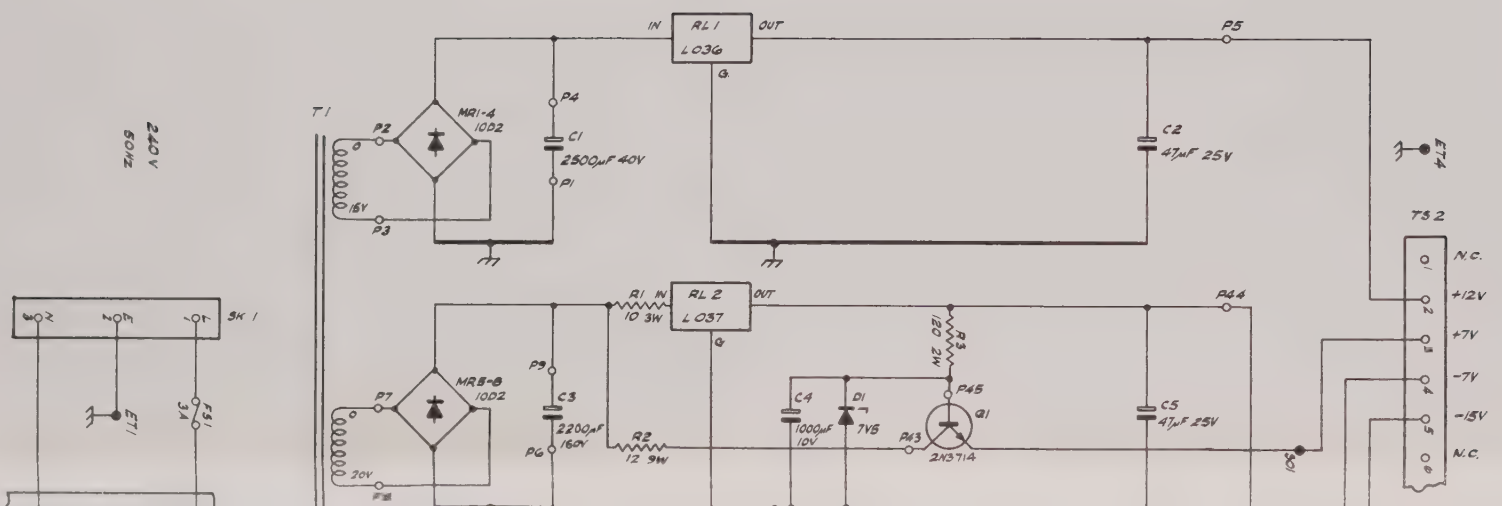


FIG. 7-5 OUTPUT BOARD COMPONENT LAYOUT


240 V
50HZ
SK 1
N
E
L
ET1
FS1
3A
T1
IN
RL 1
L036
OUT
P5
P4
P2
MR1-4
100Z
C1
2500μF 40V
15V
P1
P3
C2
47μF 25V
ET4
TS 2
N.C.
+12V
+7V
-7V
-15V
N.C.
R1 IN
10 3W
RL 2
L037
OUT
P44
P9
C3
2200μF
16OV
P7
MR8-8
100Z
20V
P6
R2
12 9W
R3
120 2W
P45
C4
1000μF
10V
D1
7V5
P43
Q1
2N3714
C5
47μF 25V
SC1

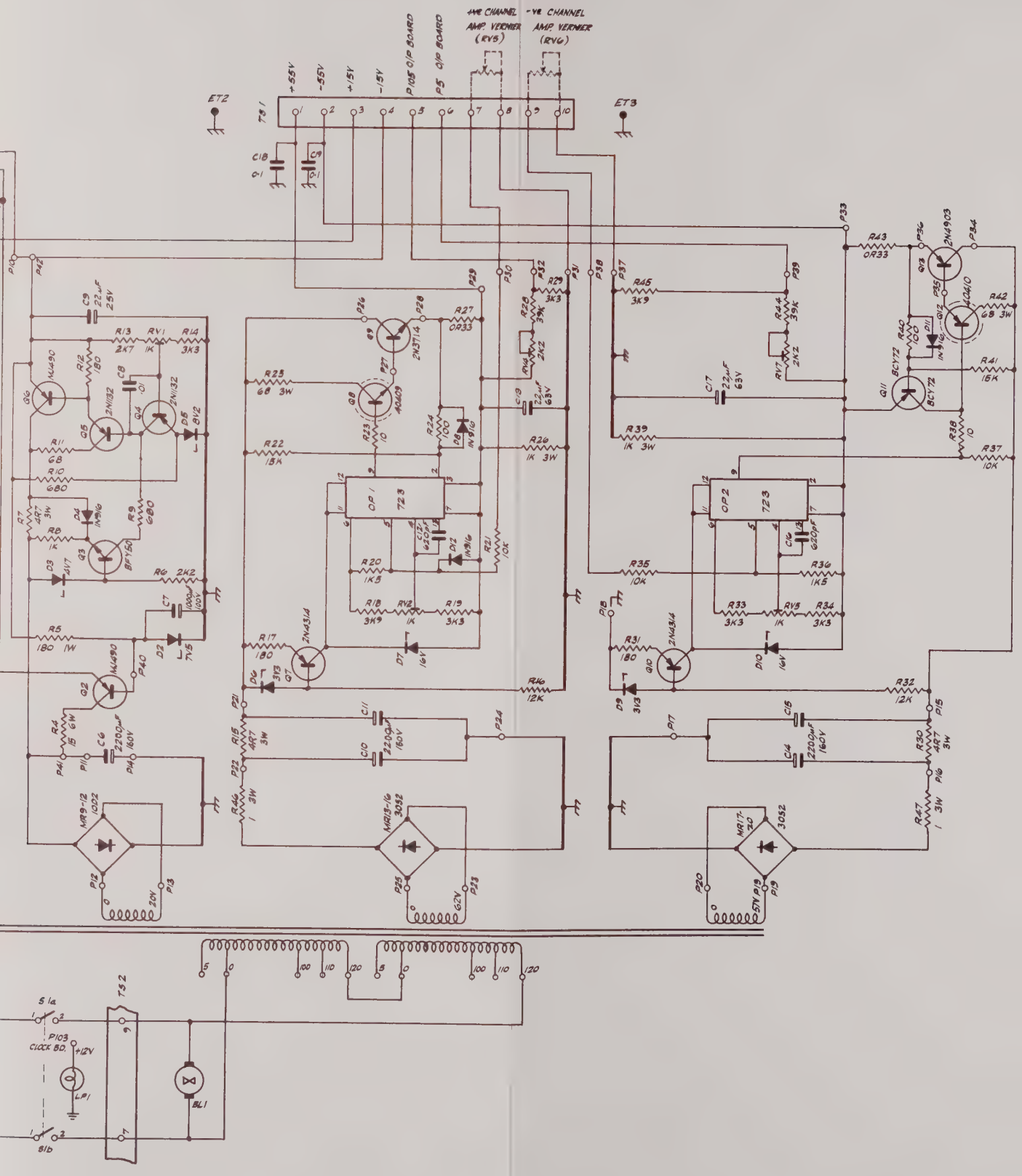


FIG. 7-6 POWER SUPPLY CIRCUIT DIAGRAM

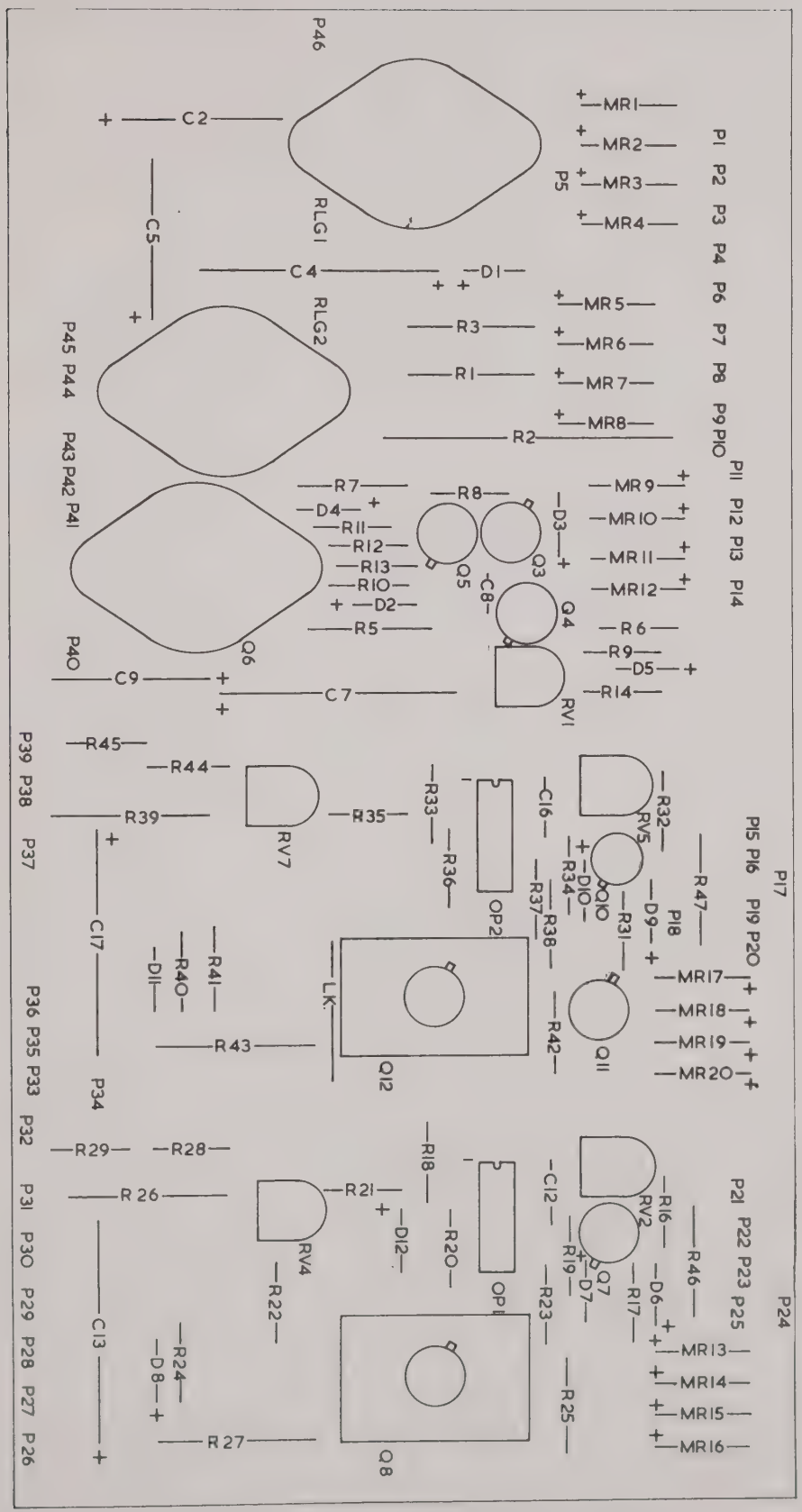


FIG. 7-7 POWER SUPPLY COMPONENT LAYOUT

R7
4R7
Q6
P10
P42

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Lyons Instruments Limited assumes no liability for the user's failure to comply with these requirements.

EARTH THE INSTRUMENT

To minimise shock hazard, the instrument chassis and cabinet must be connected to an electrical earth. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into a three-pole mains socket with earth or used with a three-pole to two-pole adapter with the earth wire (green/yellow) firmly connected to an electrical earth at the power outlet. The power inlet and mating connector of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation is present.

OBEY STRICTLY ALL WARNINGS IN THE FOLLOWING PAGES

Dangerous voltages, capable of causing death, are present in this instrument.

Use extreme caution when handling, testing, and adjusting.

SB 34496

MP MASTER
MA23374